International Journal of Agricultural Technology 2021 Vol. 17(2):479-496
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Developing the quality seed production technology for berseem (*Trifolium alexandrinum* L.) fodder

Gondal, M. R.[1*], Rizvi, S. A.[1], Hanif, M. S.[2], Mahmood, T.[3], Naseem, W.[1], Hayat, S.[2], Mustafa, S.[4], Pervez, A.[2] and Khan, A.[1]

[1]Soil and Water Conservation Research Institute, Chakwal, Pakistan; [2]Fodder Research Institute, Sargodha, Pakistan; [3]Agronomic Research Institute, Faisalabad, Pakistan; [4]Rice Research station, Bahawalnagar Pakistan.

Gondal, M. R., Rizvi, S. A., Hanif, M. S., Mahmood, T., Naseem, W., Hayat, S., Mustafa, S., Pervez, A. and Khan, A. (2021). Developing the quality seed production technology for berseem (*Trifolium alexandrinum* L.) fodder. International Journal of Agricultural Technology 17(2):479-496.

Abstract Berseem (*Trifolium alexandrinum* L.) is an important fodder crop of the region because of its palatability and nutritious nature that offers fodder in repeated cuttings almost year round. Under this study, effect of climatic variations and temporal cutting intervals on fodder production, seed vigor, seed yield and net income was assessed. The results showed significant variations in the period of flowering as well as yield characters under different cutting arrangements. Quality and production of seed reduced while the fodder tonnage increased with delaying the last cut for fodder. It was observed that last cutting taken on 20th April gave more fodder yield but low seed yield and thus income. Last cutting of *Agaiti* berseem taken on 10th March, Super late & Punjab berseem produced significantly higher number of seed per head, seed yield, 1000 grain weight and number of tillers m^{-2} on 20th March. It was concluded that all three varieties gave optimum production of quality seed while taking the last cut between 10th & 20th March with minimum temperature ranging from 8.66-22.33 ^{o}C, maximum temperature ranging from 25.91-39.79 ℃ and relative humidity of 64.40% to 46.30%.

Keywords: Berseem (*Trisodium alexandrinum*) production technology, Date of last cut, Fodder yield, Quality attributes, Seed yield

Introduction

Berseem is the main legume fodder cultivated in the south-east Asia because of its more vegetative growth, multi-cut nature, better forage output after harvesting, prolonged time of forage provision, and prominent fodder yield with outstanding delicious and excessive beneficial values of 20-21% crude protein and 62% total edible food (Yadav *et al.*, 2015). Berseem is the biggest beneficial winter forage crop in Pakistan, which is cultivated on a vast irrigated

* **Corresponding Author**: Gondal, M. R.; **Email:** riazgondal1962@gmail.com

area during winter season. It is known as "king of fodders" due to its highest tonnage capacity among fodders and it has no toxic effects. It is used as green forage during the season as well as hay or pallets during off season (Nigam *et al*., 2010). In Pakistan farmers of small land holdings contribute in mixed crop livestock farming system which constitutes the major part of agricultural productivity. It is mainly grown in the Punjab region, where small land holders possess two to three hectare, on major portion of which they grow major crops and very small portion is used for sowing of fodder crops (Cain *et al*., 2007; Dost *et al*., 2014). Animals are the most important part of farming system in Punjab and it contributes approximately forty percent (40%) in annual income of small farmers. Livestock are indispensable for production of milk & meat and for work provisions (Anwar *et al*., 2012). Fodder crops cover 16 to 19 percent of cropped area in Pakistan (Saeed *et al*., 2011). Government of Pakistan (2015) reported that Clover as *Rabi* forage crop is cultivated on 710,000 ha which produces approximately 22. 61 million tons of fresh fodder (on dry herbage basis) annually. Clover is cultivated alone as well as a mixed crop with oats and *brassica* spp. to improve the fodder yield and quality. It is also used with straws of wheat and rice for animals' feeds (Ud-Din *et al*., 2014). Clover is mostly grown as multipurpose crop such as for hay, forage and grains, with the grains often stored for planting next year (Dost *et al*., 2014). The fodder and seed yield from improved varieties is significantly higher as compared to those as obtained by small holder farmers (Govt. of the Punjab, 2014).

Berseem fodder is highly palatable due to its succulence and nutritious value as it contains 20% crude protein and 62 % total digestible nutrients. Its vegetative and reproductive phase take place at the same time leading to deprived seed setting. Because of shortage of fodder in Pakistan, it is repeatedly cut for green forage which leads to vigor loss and reduction in nutrients store for seed raw material (Singh, 1993). The success of each crop mainly depends on the availability of the quality seed which is the most critical input for the agriculture. Crop yield and biomass can be enhanced by using quality seed. Seed yield in forage crop is generally low due to more vegetative growth as well as reduced seed setting (Yadav *et al*., 2015). The demand of berseem seed is increasing day by day in Pakistan as a result seed has to be imported every year on which huge foreign reserves have to be spent. In the central region of Pakistan, Berseem is generally sown during last week of September to November after which three to four cuttings are taken till the month of March, then crop is left for seed. Amongst various factors, time of the last cut for fodder is most crucial in developing seed production technology. Because very short time is left for seed setting if the last cutting is delayed. Moreover, high air temperature and low humidity coincide with pollination and fertilization

(Singh *et al*., 2019). Less bee activity leading to poor pollination (Yadav *et al*., 2015; Asmaa *et al*., 2017) pollens infertility, post fertilization, termination of seed development (Pasumarty *et al.*, 1993), which all lead to weak seed setting. Less grains production having poor quality is because of lack in use of recommended technology for grain yield management.

Current changes in the climate condition of Pakistan have prolonged the warm season and shortened the *Rabi* cool season and extended the temperature in growing season of clover which has further effected the seed production. So, it is very necessary to change the time of last cut when berseem is left for seed to avoid the high temperature effect on pollination and fertilization of berseem. Seed production of berseem is decreased by excessive temperature at procreative phase (Iannucci and Martiniello, 1998). Grain yield of clover was mainly depending on weather condition and activity of insects especially honey bee during the blooming span (Iannucci, 2001; Bakheit *et al*., 2012). El-Zanaty, 2005) reported that yield of berseem seed is significantly influenced by date of sowing, number of cutting and topmost by the last cut date. Due to changes in climate condition, it is very important to find out the stability of berseem variety. Due to shortage of fodder, farmers often continue to take berseem cuttings up to 15th April which prompted into lower foliage retention, weak blossoming and poor quality and less seed production. The farmers often take less interest in producing clover seed causing serious seed shortage (Bakheit *et al*., 2012). Thus lack of seed availability resulted in less fodder production which affects the livestock production in Pakistan. Increase in livestock production mainly depends on availability of fodder in sufficient quantities and quality (Khan *et al.*, 2005). In developing countries like Pakistan fodder production has many folds restricted by land dearth, inadequacy of standard seed (Tufail *et al.*, 2019) and unawareness about fodder production technology and usage (Kamanzi and Mapiye, 2012). Provision of recommended seed varieties along with seed production technology to small holder farmers can enhance the assertion of leguminous forages at small scale farmer stage. Pakistan is not self-sufficient in forage seed, thus 30000 tons of seed was bought from abroad during 2014 (Farooq, 2015). The quantity and quality of livestock feed is only achieved when sufficient quantity and quality seed of fodder varieties are available.

Keeping in view the above situation of fodder and availability of quality seed in the country, the current study was conducted to devise technology for production of quality seed by optimizing the last date of fodder cutting and to investigate the effect of temperature on yield of fodder as well as yield and quality of berseem seed.

Materials and Methods

Study site description and layout of experiment

Present experimental study was conducted at Fodder Research Institute Sargodha during *Rabi* seasons of years 2015-16 to 2017-18. General weather conditions of study area are characterized as extreme hot summers and moderate cool winters. The maximum temperature reaches 50 ℃ (122 ℉) in summer and minimum temperature sometimes drops to freezing point in the winter. Soils of the area are generally loam having organic matter 0.61% pH 7.85 ±-0.11, Nitrogen 0.06 ± 0.01, $^{+}$K174 ±6.34 mg kg^{-1} and P 5.6 ±0.41.

Three popular varieties namely *Agati Berseem* (V_1) S*uper late* (V_2) and *Punjab Berseem/SB11* (V_3) were selected. Certified seed of all these verities were sown at the rate of 20 kg ha^{-1} with three replications adopting five treatment of last cutting dates viz a viz 10th March (CD_1), 20th March (CD_2), 30th March (CD_3), 10th April (CD_4) and 20th April (CD_5) each year. The experiment was laid out following randomized complete block design (RCBD) in split plot design with verities in main plots and cutting dates in sub plots having size of 6m x 3m.

The field was prepared with conventional cultivator twice with planking followed by one ploughing with rotavator. Sowing was done during the first week of October by broadcasting the seed in standing water under each treatment separately each year. Fertilizer was used @ 57-57-57 NPK kg ha^{-1}, half nitrogen and full dose of PK applied at the time of field preparation and rest of N was used after 30 days of crop sowing. All other cultural practices were kept uniform according to the recommendations of department.

Data collection on cutting date management

First cutting of fodder was obtained after fifty to fifty-five days of sowing when crop achieved 55-60 cm height followed by subsequent cuttings with last cut according to treatments of experiment. Fresh fodder yield per plot after each cut was taken with the help of spring balance and converted into fodder yield per hectare. The crop was left for seed according to experimental dates after taking the last cut of fodder. The number of tillers m^{-2} were recorded from each treatment by taking two random samples with the help of m^2 quadrate at the time of each cutting for fodder. Pre-harvest data on other parameters such as days to 50% blossoming, days to 100% flowering, days to maturity after sowing and date of last cut were recorded as per plan. Similarly post-harvest observations on various parameters such as number of tillers m^{-2} at maturity stage, seed per capsule, 1000 seed weight and seed yield were also

recorded. Seeds per capsule was counted by selecting 10 heads per treatment and 1000 grain-weight was recorded by taking three samples from each treatment. Income from fodder and seed yield per hectare was estimated as per prevailing market rates of the area (seed @ Rs 300 per kg and fodder @ Rs 100 per 40 kg).

Seed germination its vigor and dry weight of seedlings

Four samples of 100 seeds from each treatment was placed for germination test under four replications next year using top of the paper method for 7 days. Seedlings grown from this seed were grouping into normal and abnormal seedlings and counted. Germination was calculated only from normal seedlings germinated from entire seed used for germination under all four replications separately. Using the standard method (Gupta, 1993), dry weight of seedlings was then recorded. According to this procedure, ten normal seedlings were selected from germination test. These seedlings were weighed after drying at 100 ℃ for 24 hours and cooling at room temperature in desiccators with silica gel. Seed vigor index was calculated as the product of germination percentage and seedling dry weight in grams.

Data analysis

Observations recorded on various parameters as described above were tabulated and analyzed using the standard statistical parameters. Results of variance and mean differences of treatments were then compared by the LSD test at 5% probability level (Gomez and Gomez, 1984).

Results

Phenology

Blossoming phenology of plants under each treatment was noted at various intervals/stages from date of sowing to each cutting specially the last fodder cut and maturity to record the number of days in achieving various blossoming phases. A significant increase in number of days to blossoming phases was observed while delaying in the last cutting date of fodder. It was observed that number of days to 50% blossoming was decreased from 43.33 (CD_5 =20th April) to 18.77 days (CD_1 =10th March) and substantial differences were noted even among other cutting dates (Table 1). Similar results were observed for days taken to complete blossoming and to maturity whereas the duration for reproductive stage was decreased. It was noted that under the

treatment (CD_5) 20th April as last cutting date 50% blossoming, 100% blossoming and maturity were achieved after 221 days, 223 and 238 days respectively (Table 1).

Table 1. Influence of last cutting date and genotypes on flowering and maturity in berseem crop (Mean of three years)

Treatment variety/ Last cut date	**Days to 50% flowering from**		**Days to 100% flowering from**		**Days to maturity from**	
	Sowing	Last Cut	sowing	last cut	sowing	last cut
Agati Berseem (V_1)	207.33C	26.067C	212.87C	31.467C	231.67C	49.133C
Super late (V_2)	216.00A	33.80A	220.47A	39.067A	239.13A	57.533A
Punjab Berseem (V_3)	213.53B	31.933B	218.47B	37.067B	237.20B	55.600B
LSD	1.69	0.5237	1.004	1.285	0.1511	0.1511
10 March (D_1)	205.33D	43.333A	211.33D	50.333	234.0B	72.111A
20 March (D_2)	208.33D	37.333B	216.33C	45.333	235.67AB	64.333B
30 March (D_3)	211.89C	29.889C	217.0C	36.00	235.67AB	54.667B
10 April (D_4)	215.78B	23.667D	219.0B	27.00	237.0A	45.00D
20 April (D_5)	220.78A	18.778E	222.67A	20.667	237.50A	35.667E
LSD	3.3319	1.9540	0.920	0.3077	2.1755	1.5332

Considering three genotypes of berseem significant differences were noted in number of days taken to achieve 50%, 100% blossoming and maturity. Super late berseem cultivar took maximum number (216 days) for vegetative growth before the initiation of reproductive phase as compared to Punjab Berseem (214 days) and Agati Berseem (207 days). The data indicated that super late Berseem took longer period for vegetative and reproductive stages as compared to other two genotypes.

Yield parameters

Number of tillers at each cut and maturity; number of cutting for fodder and varieties as well as their interactive effect were studied and found a considerable difference in production of tillers at various cuttings and maturity. It was observed that number of tillers were consistently increased up to 3rd cut on 30th March and decreased till the last cut. Highest number of tillers (484 m^{-2}) were recorded at 3rd cut and lowest tillers (210 m^{-2}) were recorded after 5th cut.

Cultivar V_1 showed highest number of tillers (388 m^{-2}) followed by V_2 with 373 tillers-m^{-2} and V_3 with least number of tillers (366 tillers-m^{-2}) (Table 2).

Table 2. Influence of number of cuts, varieties and their interactive effect on tillers m^{-2} of berseem (Pooled three-year data)

Treatments	V1	V2	V3	Means
No. of cut 1	389.00 EF	389.67 EF	272.67 FGH	386.78 C
No. of cut 2	456.67 BC	436.67 CD	443.33 CD	445.56 B
No. of cut 3	510.00A	483.00 AB	459.00 BC	484.00 A
No. of cut 4	415.67 DE	373.33 FGH	377.67 EFG	388.89 C
No. of cut 5	443.63 GHI	336.33 HI	333.67 I	337.89 D
No. of cut 6	211.67 J	211.67 J	206.67 J	210.00 E
Means	387.78 A	373.28 AB	365.50 B	

*LSD of varieties 19.232, LSD of number of cuts 21.481 and LSD of Interaction 38.748.

The highest number of tillers (485 m^{-2}) recorded at maturity (with last cutting date (CD_2 i.e. 20th March) were statistically found at par with first cutting date (10th March) showing 484 tillers-m^{-2}. However, the minimum number of tillers (223 m^{-2}) at maturity were recorded when last cutting date was considered as CD_5 = 20th April (Table 3).

Table 3. Influence of berseem genotypes and last cut date on different parameter of berseem (Pooled three-year data)

Treatment Variety/Date	**No. of tillers at maturity**	**Grains capsule^{-1}**	**1000 grain weight (gm)**	**Germination %age**	**Vigor Index**
V1	372.20	48.20 AB	2.6933 A	83.80	1.1820
V2	369.60	47.33 B	2.5867 B	84.80	1.2133
V3	372.60	50.60 A	2.6200 AB	84.86	1.2071
LSD	NS	3.2202	0.0763	NS	NS
CD1	483.67 A	57.33 A	2.8556 A	91.22 A	1.2888 A
CD2	485.33 A	55.33 A	2.8778 A	90.33 A	1.2783 AB
CD3	381.11 B	52.00 B	2.6444 B	87.44 B	1.2414 B
CD4	283.89 C	42.89 C	2.4667 C	79.33 C	1.1494 C
CD5	223.33 D	36.00 D	2.3222 D	74.11 D	1.0460 D
LSD	24.33	2.867	0.0791	2.2293	0.0468

The combined effect of varieties with last cutting date showed that cultivar V_1 gave highest number of tillers (525 m^{-2}) after first cutting date (10^{th} march) which was statistically at par with second cutting date (20^{th} March) while other two cultivars (V_2 and V_3) produced 483 and 505 number of tillers-m^{-2} at CD2 respectively. After 5^{th} last cutting date (20^{th} April) all cultivars showed non-significant response to number tillers-m^{-2} (Table 4).

Table 4. Interactive effect of berseem genotype and last cut date on different parameters of berseem (Means of three years)

Treatment Interaction	No. of tillers at maturity	Grains capsule^{-1}	1000 grain weight(gm)	Germination %age	Vigor Index
V1*CD1	525.00 A	57.00 ABC	2.9333 AB	91.67 A	1.2923 A
V1*CD2	467.67 BC	54.00 BCD	2.8000 BCD	91.00 A	1.2817 AB
V1*CD3	385.00 D	52.67 CD	2.7000 DEF	86.67 B	1.2303 AB
V1*CD4	271.67 EF	42.33 E	2.6000 F	78.33 CDE	1.1060 D
V1*CD5	211.67 G	45.00 F	2.4333 G	71.33 F	0.9987 E
V2*CD1	442.00 C	55.00 ABCD	2.7667 CDE	91.33 A	1.2833 A
V2*CD2	483.33 ABC	53.00 CD	2.8667 ABC	90.33 AB	1.2737 AB
V2*CD3	377.67 D	50.67 D	2.6000 F	88.00 AB	1.2433 AB
V2*CD4	316.67 E	43.67 E	2.4333 G	79.33 CD	1.2010 BC
V2*CD5	228.33 FG	44.33 F	2.2667 H	75.00 EF	1.0650 DE
V3*CD1	484.00 ABC	60.00 A	2.8667 ABC	90.67 AB	1.2907 A
V3*CD2	505.00 AB	59.00 AB	2.9667 A	89.67 AB	1.2787 AB
V3*CD3	380.67 D	52.67 CD	2.6333 EF	87.67 AB	1.2507 AB
V3*CD4	263.33 EFG	42.67 E	2.3667 GH	80.33 C	1.1413 CD
V3*CD5	230.00 FG	38.67 EF	2.2667 H	76.00 DE	1.0743 DE
LSD	54.641	2.4446	0.1370	3.8612	0.0862

Number of grains per capsule and thousand grain weight

Number of grains per capsule were recorded from all experimental plots taking random samples from each plot. Influence of last cutting dates and varieties on number of grains per capsule was studied individually as well as in interaction (V*CD). Considerable effects were observed when data was compared on cultivar basis (Table 3 and 4). Maximum number of seed per capsule (51) were found in cultivar V_3 which was non-significant with cultivar

V_1 having 48 grains per capsule while V_1 was statistically at par with V_2, showing minimum grains per capsule i.e., 47 grains (Table 3). In case of date of last cut, highest number of grains per capsule (57) were recorded in CD_1 (10^{th} March) which was statistically at par with CD_2 (20^{th} March) and least number of grains per capsule were recorded in CD_5 (20^{th} April).

Results on 1000 grain weight (gm) revealed that date of last cut for fodder and varieties as well as their interactive effect was also notable (Table 3 and 4). Statistically highest thousand seeds weight (2.6933 gm) was recorded in V_1 which was at par with V_3 (2.62 gm) followed by V_2 (2.5867 gm) as given in Table 3. Last cutting date CD_2 produced maximum 1000 grain weight (2.8778gm) which was at par with CD_1 (2.8556 gm) followed by all other forage cutting dates. Considering the interactive effect of cultivar with date of last cut for fodder, maximum 1000 grain weight (2.9667gm) were recorded from V_3*CD_2 that was statistically at par with V_1*CD_1, V_2*CD_2 and V_3*CD_3 (2.9333, 2.8667 and 2.8667 respectively) as given Table 4. While the minimum 1000 grains weight (2.2667 gm) were noted from $V_{3*}CD_5$ and $V_{2*}CD_5$ which was statistically lower than V_1*CD_5 (2.4333gm).

Seed germination and its vigor

Seed collected from all treatments was placed under germination adopting standard procedure. A decline in germination percentage from 91.22 to 74.11 in the seed was observed among the seed samples obtained from crop with last cut dates of fodder (CD_1 to CD_5 i.e. 10^{th} March to 20^{th} April). However, no notable differences were observed between treatments CD_1 & CD_2, but a considerable reduction in germination of seed obtained from other three cutting dates (CD_3, CD_4 & CD_5) was observed (Table 3). Among varieties (V_1, V_2 & V_3) non-significant differences were observed in germination %age. The highest germination percentage (91.22) was recorded in the seed harvested from CD_1 which was statistically at par with CD_2 (90.33%). The interactive effect showed significant difference in germination %age. The highest germination %age (91.67) was recorded in V_1*CD_1 which was statistically at par with V_2*CD_1, V1*CD_2, V_3*CD_1, V_3*CD_2, and V_3*CD_3 having germination percentage 91.33, 91.00, 90.67, 89.67 and 87.67 respectively (Table 4).

Management of last cut date for fodder and seed production

Average of three years data showed that highest fresh fodder yield (164.00 t ha^{-1}) was obtained from CD_5 whereas minimum fresh fodder tonnage (120.85 t ha^{-1}) produced from CD_1 while comparing the varieties, the highest fresh fodder yield (143.69 t ha^{-1}) was obtained from V_2 which was statistically

at par with V_1 and followed by V_3 (Table 5). It was also observed that the variety V_1 produced maximum seed yield (0.7489 t ha^{-1}) which was at par with other cultivars (V_3).

Table 5. Influence of berseem genotype and last cut date on seed & fodder yield and income. (Means of three year)

Treatment Variety/Date	Fodder yield t ha^{-1}	Seed yield t ha^{-1}	Income fodder (Rs ha^{-1})	Income seed (Rs ha^{-1})	Total income (Rs ha^{-1})
V1	140.07 AB	0.7489	350452 B	222680	575230
V2	143.69 A	0.7067	359222 A	212000	571233
V3	139.55 B	0.7357	349552 B	220720	570270
LSD	3.7765	NS	8269.7	NS	NS
CD1	120.85 E	0.9094 A	302136 E	269500 A	574972 B
CD2	133.51 D	0.9287 A	333783 D	278600 A	612378 A
CD3	140.53 C	0.7654 B	351331 C	229633 B	580967 B
CD4	146.62 B	0.7067 B	367669 B	212000 B	579667 B
CD5	164.00 A	0.3420 C	410456 A	102600 C	513239 C
LSD	1.6715	0.0862	37552	24663	29777

The interactive effect of cultivar and date of last cut showed that the highest fresh fodder yield (167.33 t ha^{-1}) was obtained from V_3*CD_5 which was statistically at par with V_2*CD_5 and followed by V_1*CD_5 (Table 6). Thus the production fodder was increased with delay in last cut date contrarily seed production decreased and germination effected after CD_3. Amongst the date of last cut, it was observed that CD_2 was gave the highest seed yield (0.9287 t ha^{-1}) whereas the lowest seed yield (0.3420 t ha^{-1}) was obtained from the treatment CD_5 i.e. (Table 6). Under the interaction the maximum grain yield (0.9953 t ha^{-1}) was recorded from V_1*CD_1 which was at par with V_1*CD_2, (0.9167 t ha^{-1}), V_2*CD_2 (0.9163 t ha^{-1}), V_3*CD_1 (0.9017 t ha^{-1}) and V_3*CD_2 (0.9530 t ha^{-1}) while the minimum yield was observed from V_1*CD_5 (0.3020 t ha^{-1}).

Economics of fodder and seed production per unit area

The major part of income from berseem crop came from Fodder production. Although income from seed was comparatively low but seed production is essential to ensure the availability of seed and reduce input cost of farmers for next sowing. Highest income from fodder (Rs 410456 per ha) was obtained from CD_5 while the lowest income (Rs. 302136 per ha) was obtained

from CD_1. In case of seed, statistically highest income (Rs. 278600 per ha) was observed from CD_2 which was statistically at par with the income (Rs. 269500 per ha) out of CD_1 while the lowest income (Rs. 102600 per ha) was achieved from CD_5. The highest combined income (seed+fodder) (Rs. 612378 per ha) was obtained from CD_2 which was followed by CD_3 (Rs. 580967 per ha), CD_4 (Rs. 579667 per ha) and CD_1 (Rs. 574972 per ha) and (Rs. 513239 per ha) CD_5.

Table 6. Interactive effect of berseem genotypes and last cut date on seed & fodder yield (t ha^{-1}) and income (Rs ha^{-1}) (Means of three year)

Treatment Variety/Date	Fodder yield	Seed yield	Income fodder	Income seed	Total income
V1*CD1	123.00 H	0.9953 A	307500 G	288600 A	606100 AB
V1*CD2	131.67 G	0.9167 ABC	329175 F	275000 AB	604167 AB
V1*CD3	139.10 EF	0.7990 BCD	347750 E	239700 BCD	587450 ABC
V1*CD4	146.33 CD	0.7317 E	365825 D	219500 CD	585333 ABC
V1*CD5	160.27 B	0.3020 F	402008 B	90600 E	493100 D
V2*CD1	120.83 H	0.8313 BCDE	302083 GH	249400 ABC	551438 BCD
V2*CD2	137.20 F	0.9163 ABC	343000 E	274900 AB	617900 A
V2*CD3	145.17 D	0.7379 DE	362917 D	221900 CD	584817 ABC
V2*CD4	150.83 C	0.6883 E	377083 C	206500 D	583583 ABC
V2*CD5	164.41 AB	0.3577 F	411025 AB	107300 E	518383 CD
V3*CD1	118.73 H	0.9017 ABCD	296825 H	270500 AB	567333 ABC
V3*CD2	131.67 G	0.9530 AB	329175 F	285900 AB	615067 AB
V3*CD3	137.33 F	0.7577 CDE	343325 E	227300 CD	570633 ABC
V3*CD4	142.71 DE	0.7000 E	360100 D	210000 CD	570083 ABC
V3*CD5	167.33 A	0.3663 F	418333 A	109900 E	528233 CD
LSD	4.5316	0.1627	10005	47428	30284

Discussion

Last fodder cutting date management

Timing for last cutting of fodder among three genotypes of berseem was studied based on phenology by selecting five dates starting from 10^{th} of March with 10 days interval. Although, phenology is one of the inherited property of a specific variety, but even it was observed that penology was influenced by the

control practices with respect to cutting and climatic conditions. Because plant needs certain vegetative growth prior to starting of reproductive stage, thus delay in the last cut increased the number of days from sowing to blossoming. Similar findings were reported by other researchers like Sardana and Narwal (2000). Yadav *et al*. (2015) who observed that the interval from blossoming to full growth of seed was substantially enhanced in berseem with delay in last cutting. Duration of vegetative phase was continuously increased with the delay of last cut date while reproductive phase duration decreased. It was found that when last cutting date of fodder delayed up to 20th April, vegetative phase took highest number of days (221 days) and reproductive phase took minimum number of days (17 days). Thus, the number of days from sowing to blossoming and maturity of seed is reciprocally related to the lasts cutting dates. Seed yield followed the trends of reproductive phase. These changes may be due to the interactive effect of various weather conditions on blossoming and seed maturity especially the increase in sun shine hours decreased the flowering to maturity duration (Table 1). Yadav *et al*. (2015) had also reported similar trends and found that transition from vegetative to reproductive stages in berseem is affected by photo and thermo periods. Interactive influence of different varieties and date of last cut was also found significant. Maximum number of days from sowing to 50 % blossoming (223 day), 100% blossoming (225 days) and days to maturity (240 days) were recorded in V_2*CD_5 and minimum numbers of days (198.33, 205.33 and 228 days) were recorded in V_1*CD_1 (Table 7).

Table 7. Influence of interaction of date of last cut and genotype on flowering and maturity in berseem. (Means of three years)

Treatment Interaction	Days to 50% flowering from		Days to 100% flowering from		Days upto maturity from	
	Sowing	Last Cut	sowing	last cut	sowing	last cut
V_1 X CD_1	198.33 I	37.333 C	205.33 J	44.333 E	228.00 H	66.00 B
V_1 X CD_2	202.0 HI	31.00 D	210.33 I	39.333 F	229.67 GH	58.333 C
V_1 X CD_3	208.67 FG	26.667 E	213.67 H	32.667 I	232.33 FG	51.333 E
V_1 X CD_4	212.33 DEF	20.0 G	215.67 G	23.66 L	232.67 EF	41.667 G
V_1 X CD_5	217.33 PC	15.333 H	219.33 DE	17.33 N	234.33 DEF	32.333 I
V_2 X CD_1	211.33 EFG	47.333 A	215.33 G	54.333 A	238.00 ABC	76.00 A
V_2 X CD_2	212.33 DEF	41.333 B	220.33 CD	49.333 C	239.67 AB	69.333 B
V_2 X CD_3	214.33 CDE	32.333 D	219.67 DE	38.667 G	238.33 ABC	57.33 CD
V_2 X CD_4	218.67 ABC	26.667 E	221.67 C	29.667 J	239.67 AB	47.667 F
V_2 X CD_5	223.33 A	21.333 FG	225.33 A	23.333 L	240.00 A	38.333 G
V_3 X CD_1	206.33 GH	45.333 A	213.33 H	52.333 B	236.0 CDE	74.333 A
V_3 X CD_2	210.67 EFG	39.667 BC	218.33 EF	47.333 D	237.67 ABCD	66.333 B
V_3 X CD_3	212.67 DFF	30.667 D	217.67 F	36.667 H	236.33 BCDE	55.333 D
V_3 X CD_4	216.33B CDE	24.333 EF	219.67 DF	27.667 K	237.67 ABCD	45.667 F
V_3XCD_5	221.67AB	19.667G	223.33B	21.333M	238.33ABC	36.333H
LSD	5.4159	3.0691	1.4299	0.4766	3.3735	2.3797

Similar to vegetative growth, it was observed that number of tillers were decreased with increasing the number of cuttings i.e. delaying the last cut after 30th March resulted in reduction of tillers in reproduction. Interactive influence of different varieties and date of last cut was also significant. The maximum tillers (525 m^{-2}) were recorded in V_1 at 1st cutting time and lowest tillers (212 m^{-2}) were noted in V_1 at 5th cutting time (Table 4). Nigam *et al*. (2010) also reported such phenomenon in berseem. Similarly, last cutting dates and interaction of varieties with cutting dates (V*CD) were studied and found that dates of last cutting notably influenced the number of tillers m^{-2} at the time of maturity however varieties have non-significant effect on number of tillers m^{-2} at maturity when last cutting date is kept as CD_5 20th April (Table 3 and 4). A similar trend was reported by Surinder *et al*. (2019), who observed that the maximum number of shoots m^{-2} were obtained at the time of cutting on 25th March followed by the cutting on 5th and 15th April.

Investigation on production of grains per capsule revealed that maximum number of grains per capsule (60) were recorded from cultivar (V_3) when last cutting was taken on 10th March (CD_1) which was statistically at par with (V_3*CD_2, V_1*CD_1 and V_2*CD_1) (Table 4). Minimum number of grains per capsule (34) were recorded from interaction of V_2*CD_5 which was statistically at par with V_3*CD_5 and V_1*CD_5. Results of current study on number of grains per capsule were comparable with the findings of Yadav *et al*. (2015) and Din *et al*. (2014). The highest grains capsule^{-1} in the treatment CD_1 might be due to longer reproductive phase and a smaller number of cutting for fodder which resulted in higher production and transfer of photosynthesis from source of sink (Surinder *et al.*, 2019).

Data analysis on thousand grain weight indicated that detain in the forage cuttings decreased the 1000 grains weight however, V_1 showed statistically less decrease in 1000 grains weight as compared to other two genotypes (i.e., V_2 and V_3). These results were supported by Sardana and Narwal (2000). Reduction in thousand grain weight in response to delay in date of last cut for forage could be due to several external factors like temperature and photo period. Increasing difference between minimum and maximum temperatures with delay in the last cut of fodder could be the possible cause of reduction in vegetative and reproductive stages and movement of pollinators. Similar findings were reported by other researchers (Singh and Kang, 2004; Puri *et al*., 2007 and Yadav *et al.*, 2015).

The results on germination of seed obtained from various treatments revealed that only cultivar V_3 significantly behaved better to CD_3 (30th March) as compared to both other cultivars. All other results of interactions showed significant variation in germination %age. Possible reason of this behavior of other treatments was the reduction in vegetative and reproductive stages as well

as the rising temperature after 3rd quarter of March till April. The seedling vigor was assessed through vigor index and found considerable variation with delay in date of last cut except CD_1 and CD_2 those were statistically at par and presented highest vigor index (1.2888 and 1.2783) respectively (Table 3). These results were in agreement with the finding of research study conducted by Yadav *et al*. (2015); Sardana and Narwal (2000).

It was also observed that production of fresh forage and seed was considerably effected by the last cutting dates when data was pooled for three years (Table 5). The fresh forage yield increased steadily with each consecutive detains in last date of cut till 20 April (CD_5) while the seed yield behaved contrarily. More number of total cuts in CD_5 as compared to all other treatments of cutting resulted in maximum yield, however it effected the vigor and yield of seed resultantly the germination. This finding is logical and in agreement with Sardana and Narwal (2000); Surinder *et al.* (2019). Results of seed production from various treatment indicated that grain yield was reduced continuously by detain in last cutting of fodder as found by Sardana and Narwal (2000). Surinder *et al.* (2019) reported that "Egyptian clover planted on 10th September and taking the last cut of forage on 15th April produced minimum seed". Higher grain yield (0.9287 t/ha) obtained from CD_2 indicated that more vegetative growth period resulted in higher seed yield and the opportunity of pollination and favorable climatic condition for early date of last cut contributed in achieving maximum seed yield. Similar findings were reported by Yadav *et al.* (2015). The investigation revealed that the cumulative effect of physiologically mature plants and most favorable exposure of development period with suitable climatic condition contributed in yield enhancement. Less number of cuttings resulted in opportunity of nutrients storage for regeneration, better production and transfer of photosynthate from source to sink and thus enhanced the yield. These results were comparable with the findings by Surinder *et al.* (2019) and Singh (1993). The results further revealed that CD_1 was most suitable time for V_1 and CD_2 for V_2 & V_3. These results showed that 10th March to 20th March was most suitable period for last cut of fodder because after that berseem initiate flowering during the second fortnight of April. During the month of April the maximum temperature did not exceed from 38.3 ^oC during all three years of study (2016-2018) with minimum as low as 19.4 ^oC (Table 8), which was highly favorable for blossoming and pollination. Moreover, during these climatic condition activities of honey bees enhanced the pollination which played major role in grain formation by tripping the blooms. Medeiros *et al.* (1995); Iannucci and Martiniello (1998); Bakheit *et al.* (2012) reported that "higher temperatures during flowering reduce the insect pollination and increase physiological losses of pollinated flowers''. These results were also supported by Asmaa *et al.* (2017). Dixit *et al.* (1989) and Yadav *et al.* (2015)

who concluded that the higher temperature not only influences the bees (main pollinators) activity but also decreases the pollen fertility resulting in decreased seed setting in crops like berseem where mechanism of tripping is required for seed setting.

Table 8. Weather parameters during last cut dates for three growing seasons

Seasons/ parameters decades	2016			2017			2018		
	Max. Temp ^{O}C	Min. Temp ^{O}C	Humidity %	Max. Temp ^{O}C	Min. Temp ^{O}C	Humidity %	Max. Temp ^{O}C	Min. Temp ^{O}C	Humidity %
10-Jan	21.19	8.44	68.04	20.87	10.1	70.15	23.33	7.44	55.02
20-Nov	21.3	8.4	67.4	24.85	12.5	67.03	22.5	10.88	61.38
21-28	27.57	12.66	60.02	25.66	10.8	48.98	25.25	14.75	63.11
10-Jan	27.4	16.4	64.5	24.2	14.1	59.46	27.7	14.9	57.97
20-Nov	23.7	15.4	72.15	25.1	12	56.45	30.7	17.2	49.52
21-31	30.73	17.91	51.02	34	20.45	46.23	32.18	18.09	48.42
10-Jan	32.07	20.8	51.5	32.2	19.4	45.97	33.5	21	52.47
20-Nov	35.8	23.2	38.12	41.2	23.5	29.7	33.2	21.4	49
21-30	38.1	22.9	30.8	36.6	23	41.45	38.3	22.4	38.45
10-Jan	36.85	24	48.88	36.16	24	41.15	34	22	48.97
20-Nov	39.6	25.24	44.22	38.66	25.55	42.98	35.33	24.25	44.8
21-31	39.12	25.75	45.32	38.5	27.12	44.6	41.77	24.87	26.14

The economic return from berseem crop in terms of total income was also calculated by combining maximum income from both fodder as well as seed. It was observed that the maximum economic return came from CD_2 (20^{th} March). It is the time when optimum vigor of seed is obtained which is additional benefit. Further the last cut of fodder up to 3^{rd} week of March provides sufficient time to have 3-4 cuts for fodder when crop was sown during 1^{st} and 2^{nd} week of October. This means that the date of last cut of fodder up to 20^{th} March can provide a balanced fodder and seed yield. These results are supported by Sardana and Narwal (2000) who reported that "the maximum net return were achieved when last cut of fodder was taken on 2^{nd} March whereas last cut taken on 1^{st} April and 11^{th} April produced lowest net return".

On the basis of the results of study, it is suggested that seed yield and income per unit area can be enhanced with delay in last cut for fodder maximum up to 20^{th} March and will reduce as go beyond till April. Although the fodder tonnage increased but seed quality and yield decreased. Berseem required temperature ranged from $15^{0}C$ to $38^{0}C$ and relative humidity ranging

from 60.70 to 38.69 % for completion of vegetative and reproductive phases successfully and this climatic condition prevail during the 2nd to 3rd week of March. Therefore it is recommended that last cutting of berseem for fodder must be completed till 3rd week of March and/or adjusted the time according to temperature range of 15^0C to 38^0C. This study also indicated a cue for further investigation on the relationship between accumulation of photoperiods, appropriate temperature and time for flowering.

References

Anwar, M. Z., Khan, M. A., Saeed, I., Ali, A., Zahid, S. and Majid, A. (2012). Small farmer's perceptions regarding improved fodder and forage varieties: Results of participatory on farm research. Pakistan Journal of Agriculture Research, 25:295-306.

Asmaa, A. M., Bakheit, B. R., Teama, E. A. and Fathy, F. M. (2017). Effect of planting date, variety and their interaction on seed yield and its components of Egyptian clover (*Trifolium alexandrinum* L.). Assiut Journal of Agricultural Sciences, 48:1-11.

Bakheit, B. R., Ali M. A. and Helmy, A. A. (2012). The influence of temperature, genotype and genotype x temperature interaction on seed yield of berseem clover (*Trifolium alexandrinum* L.). Asian Journal of Crop Sciences, 4:63-71.

Cain, P., Anwar, M. and Rawlinson, P. (2007). Assessing the critical factors affecting the viability of small-scale dairy farms in the Punjab region of Pakistan to inform agricultural extension programs. Agricultural System, 94:320-330.

Din, S., Ullah, I., Khan, G. D., Ramzan, M., Ahmad, B. and Hameed, M. (2014). Sowing dates and irrigation schedule influence on yield and yield components of berseem in district Peshawar. Journal of Natural Sciences Research, 4:91-95.

Dixit, O. P., Singh, U. P. and Gupta, J. N. (1989). Significance of pollination in seed setting efficiency of berseem (*Trifolium alexandrinum* L.). Journal of Agronomy and Crop Sciences, 162:93-96.

Dost, M., Misri, M. B., El-Nahrawy, Khan, S. and Serkan, A. (2014). Egyptian Clover (*Trifolium alexandrinum* L.); King of Forage Crops. Cairo: Food and Agriculture Organization (FAO) of the United Nations.

El-Zanaty, I. A. (2005). Influence of sowing date on forage and seed yield on some new varieties of Egyptian clover. Minia Journal of Agricultural Research Development, 25:757-780.

Farooq, O. (2015). Agriculture, economic survey of Pakistan. In Pakistan Bureau of Statistics. Islamabad: Ministry of Finance, Government of Pakistan.

GOP (2014). Improved forage varieties and their yield potentials [Online]. Ayub Agricultural Research Institute. http://www.aari.punjab.gov.pk/institutes-sections/fodder-research-institute/ fri-achievements.

Gomez, K.A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research 2nd Edition. New York: John Wiley & Sons.

Gupta, P. C. (1993). Seed vigor testing. In: P. K. Agrawal (ed). Hand book of seed testing, DAC, Ministry of Agriculture, Government of India. New Delhi. pp.242-249.

Iannucci, A. (2001). Effect of harvest management on growth dynamics, forage and seed yield in berseem clover. European Journal of Agronomy, 14:303- 314.

Iannucci, A. and Martiniello, P. (1998). Analysis of seed yield components in four Mediterranean annual clovers. Field Crops Research, 55:235-243.

Kamanzi, M. and Mapiye, C. (2012). Feed Inventory and Smallholder Farmers' Perceived Causes of Feed Shortage for Dairy Cattle in Gisagara District, Rwanda. Tropical Animal Health Production, 44:1459-1468.

Khan, A. A., Alam, S. and Khan, H. (2005). Performance of berseem varieties at Peshawar. Sarhad Journal of Agriculture, 21:317-321.

Medeiros, R. B., Jacques A. V. A. and Nabinger, C. (1995). Alfalfa (*Medicago sativa* L.) seed production under different row spacing and plant population in the seeding year. Proceedings of the 3rd International Herbage Seed Conference. Halle (Saale), Germany, pp.331-333.

Nigam, P. N., Srivastava, R. L. and Verma, N. C. (2010). Effect of different cutting and growth retardant (cycocel) on higher forage yield and seed yield in berseem (*Trifolium alexandrinum* L.) International Journal of Plant Sciences, 5:660-663.

Pasumarty, S. V., Matsumura, T., Higuchi, S. and Yamada, T. (1993). Causes of low seed set in white clover (*Trifolium repens L.*).Grass and forage science, 48:79-83.

Puri, K. P., Tiwana, U. S. and Bhardwaj, B. L. (2007). Effect of time of last cut on the seed yield of berseem (*Trifolium alexandrinum* L.) Range management and agroforestry, 28:318-319.

Saeed, B., Gul, H., Wahab, S., Durrani, Y., Haleema, B., Ayub, M., Muhammad, A., Said A. and Ahmad, I. (2011). Effect of phosphorus and potassium on seed production of Berseem. African Journal of Biotechnology, 10:13769-13768.

Sardana, V. and Narwal, S. S. (2000). Influence of time of sowing and last cut for fodder on the fodder and seed yields of Egyptian clover. The Journal of Agricultural Science, 134:285-291.

Singh, A. and Kang, J. S. (2004). Effect of agro techniques on seed production potential of new berseem cultivar BL-42. Range Management and Agroforestry, 25:80-81.

Singh, A., Sharma, R. and Singh, A. (2019). Effect of Date of Sowing and Cutting Management on Seed Yield in Berseem (*Trifolium alexandrinum* L.). Journal of Krishi Vigyan, 8:96-100.

Singh, V. (1993). Berseem (*Trifolium alexandrinum* L.*)* a potential forage crop. Outlook in Agriculture, 22:49-51.

Surinder, Kanwaljit and Tarandeep (2019). Effect of time of sowing and last cut on green fodder and seed production in Berseem (*Trifolium alexandrinum* L.). Journal of Pharmacognosy and Phytochemical, 1:234-237.

Tufail, M. S., Krebs, G. L., Southwell, A., Piltz, J. W. and Wynn, P. C. (2019). Seeding rate effects on yield components and forage quality of *Agaiti* Berseem-2002–an improved variety of berseem clover. Journal of Crop Improvement, 33:522-535.

Ud-Din, S., Ullah, I., Khan, G. D., Ramzan, M., Ahmad, B. and Hameed, M. (2014). Sowing dates and irrigation schedule influenced on yield and yield components of Berseem in district Peshawar. Journal of Natural Sciences Research, 4:91-95.

Yadav, P. S., Vijay, D. and Malaviya, D. R. (2015). Effect of cutting management on seed yield and quality attributes of tetraploid berseem. Range Management and Agroforestry, 36:47-51.

(Received: 27 July 2020, accepted: 16 February 2021)